Goldschmidt 2000
September 3rd–8th, 2000
Oxford, UK.

Journal of Conference Abstracts
Volume 5(2), 517

Coupled He-Pb Isotope Relationships Along the Reykjanes Ridge with Implications for Plume Structure and the Helium-Paradox

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We present 36 new helium isotope ($^3He/^4He$) and abundance results ([He]) obtained by crushing glassy rims of basaltic lavas obtained along an approx. 800 km transect of the Reykjanes Ridge (RR). Recovery depths of dredged lavas lie between approx. 275 metres at 63 ºN and approx. 2 km at 57 ºN. There appears a strong geographic control on both the helium isotope and concentration characteristics. In a north-to-south traverse starting at 61.3 ºN, $^3He/^4He$ ratios decrease from values ~17R_A (where R_A is the atmospheric $^3He/^4He$ ratio) to ~11R_A at 2km depths. [He] is inversely correlated with $^3He/^4He$, and varies over 2 orders of magnitude with maximum values ~5 x10^{-6} cm^3STP/g in the south of the section. Glasses along this transect have MORB-like water abundances ([H_2O] ~0.2 wt%). In contrast, $^3He/^4He$ ratios north of 61.3° show no correlation with latitude nor with [He]. $^3He/^4He$ ratios vary between 11 and 16R_A, and [He] are mostly < 0.1 x 10^{-6} cm^3STP/g. These samples have significantly higher [H_2O] - approx. twice that of the southern section.

Samples along the southern RR show strong relationships in He-Pb and He-Nd isotope space but not in He-Sr. There are no correlations for samples north of 61.3º. The correlations are consistent with 2 different binary mixing scenarios. First, if all data are included, we obtain a linear mixing curve in He-Pb isotope space with a K-value = 1 (K = $(He/Pb)_{plume}/(He/Pb)_{DMM}$). Extrapolation of the He-Pb trajectory to the most radiogenic $^{206}Pb/^{204}Pb$ ratio observed in the sample suite (18.70) would predict a plume end-member ratio of >30R_A – in agreement with published values for central Iceland (Hilton et al., 1999). Likewise, extrapolation to 8R_A – the nominal value for depleted MORB mantle (DMM) - would give a $^{206}Pb/^{204}Pb$ value of 18.04 – again in concert with values predicted for plume-free MORB mantle (Taylor et al., 1997). In the second scenario, which excludes samples south of 58.2o, we obtain a binary mixing curve with K = 3: in this case, the plume end-member is estimated at ~20R_A and $^{206}Pb/^{204}Pb$ would tend toward 18.2 at ~8R_A. Rather than Iceland plume, we suggest that the notion of a slightly lower $^3He/^4He$ plume sheath mixing with "enriched" or plume-tainted depleted MORB-mantle would accommodate these characteristics. In either scenario, the He-Pb correlations allow a first-order estimate of the concentration contrast of helium between the two end-members. Assuming that Pb_{plume} = approx. 0.185 ppm (Sun and McDonough, 1989) and Pb_{DMM} = approx. 0.05 ppm (e.g. Chauvel et al., 1992) then He_{plume}/He_{DMM} = 3 (model 1) and 9 (model 2) with a respective $^3He_{plume}$ enrichment of ~12 and 24 over $^3He_{DMM}$. Although the relative enrichment in plume [^3He] is not as great as predicted from modeling studies (e.g. Porcelli and Wasserburg, 1995), the RR results would appear to reinforce traditional notions of the ^3He distribution in the mantle as opposed to more recent views – termed the He-paradox (Anderson, 1998) - which call for higher [^3He] in the DMM reservoir.

The He-paradox is based on the observation that in many plume (i.e. high $^3He/^4He$) lavas, the [^3He] is generally lower than that observed in MORB glasses. RR samples north of 61.3° give an indication of the circumstances that may cause this effect. For these samples, CO_2 retention (the principal carrier phase of magmatic He) is poor as a result of 2 factors: low confining pressure (eruption depths < 775 m) and high water contents (which decreases CO_2 solubility). Volatile loss from these magmas would result in low [^3He] but $^3He/^4He$ ratios would remain unaffected. However, volatile-poor magmas are susceptible to addition of radiogenic helium (~0.05R_A) and any crust-mantle interaction would lower ($^3He/^4He$) ratios without appreciably increasing [^3He]. This would account for the variability in ($^3He/^4He$) values north of 61.3º. The same effect is likely to occur at Loihi Seamount where eruption depths are shallow (approx. 1 km) and lavas have [H_2O] greater than MORB. Therefore, the concept of a He-paradox may be related to considering plume lavas (mainly from Loihi Seamount) which are more highly degassed than MORB samples. In this respect, the southern RR where samples are erupted under greater water depths and have lower water contents possess circumstances which minimize degassing and hence help conserve isotope relationships that bear on source processes.

Hilton DR, Gronvold K, Macpherson CG & Castillo PR, *LPI Contribution*, **971**, 125, (1999).

Taylor RN, Thirlwall MF, Murton BJ, Hilton DR & Gee MAM, *Earth. Planet. Sci. Lett.*, **148**, E1-E8, (1997).

Sun, S & McDonough WF, *Geological Society Special Publication*, **42**, 313-345, (1989).

Chauvel C, Hofmann AW & Vidal P, *Earth. Planet. Sci. Lett*, **110**, 99-119, (1992).

Porcelli D & Wasserburg GJ, *Geochim. Cosmochim. Acta*, **59**, 4921-4937, (1995).

Anderson DL, *Proc. Ntl. Acad. Sci*, **95**, 4822-4827, (1998).